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Physical characteristics of Chinese Hakka

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Using standard and internationally validated methods, 86 anthropologic characteristics were determined in 650 male (305 from urban areas and 345 from rural areas) and 704 female (331 from urban areas, 373 from rural areas) Chinese Hakka adults living in Guangdong and Jiangxi. The data were used to calculate 24 anthropologic indices, which were analyzed statistically. The physical characteristics of Hakka subjects were analyzed and compared with reference ethnic data. There were four main findings of this study. First, a small proportion of Hakka adults had an eye fold on the upper eyelid, but a large proportion had a mongoloid fold. The eye slits were narrow in most adults, had a medium nasal root height and straight bridges, and most of the external angles were prominent. The nasal base was upturned in most men. The distributions of the three types of nasal base in women were similar. The proportions of subjects with middle and high alae nasi heights were high and similar. Males with a maximum nostril diameter were mostly classified as transverse and oblique, while many women were classified as transverse and had relatively wide alae nasi. The round lobe type was the most common. Upper lip skin height was mostly classified as medium. Lips were classified as thin. The hair was black, eyes were brown, and the skin was yellowish. Second, the head length was long in male Hakka. The minimum frontal breadth, face breadth, lip height, and interocular breadth were similar to those of North-Asian populations. Meanwhile, head breadth, morphological facial height, nose breadth, mouth breadth, and nose height were similar to those of South-Asian populations. Head length was long in female Hakka. The minimum frontal breadth, face breadth, lip height, and interocular breadth were similar to those of North-Asian populations. Head breadth, nose breadth, and mouth breadth were similar to those of South-Asian populations. Third, the stature of male and female Hakka in urban and rural areas was classified as medium. The proportions of male and female Hakka classified as mesocephaly (length-breadth index of the head), hypsicephalic type, metriocephalic type (breadth-height index of the head) mesorrhiny, long trunk, subbrachyskelic type, broad shoulder breadth, and narrow distance between iliac crests were higher than those of other types. Finally, principal component analyses showed that the physical characteristics of Hakka were between those of South-Asian and North-Asian ethnic populations, but were generally closer to those of North-Asian populations in China.

somatoscopy, ethnicity, Hakka, China

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Hakka is a branch of the Han ethnic group, and is one of the far-reaching ethnic groups that have wide distribution. The ancestral home for many individuals of Hakka descent is northern China. Since the Yongjia rebellion in West Jin, Han residents who originally lived in the central plains of China migrated to Guangdong, Jiangxi, and Fujian, and lived with local residents. In general, it is believed that the Hakka population differentiated and became a branch of Han during the Southern Song Dynasty. A relatively stable

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population of Hakka became established after about 1000 years. Since then, many Hakka have migrated from Meizhou throughout southern China, and worldwide [1].

The name Hakka was first used by Guangfu Chinese. Hakka was originally used to refer to the third person and was gradually accepted as the ethnic name. Now, many people are proud to call themselves Hakka. The four Hakka states are Meizhou, Ganzhou, Huizhou, and Tingzhou. Meizhou is often referred to as the capital of the global population of Hakka because it has the highest population of Hakka, and many Hakka emigrated from Meizhou. Ganzhou is considered the ancestral home of Hakka, and is known as the "Hakka cradle".

Hakka is one of the seven major Chinese dialects. Hakka dialects were formed as early as the Southern Song Dynasty through the inheritance of many language tones from the five dynasties and Song dynasties.

The Hakka area is divided into "pure" and "impure" Hakka counties. There are 48 pure Hakka counties and cities in regions bordering Guangdong, Fujian, and Jiangxi. Although the total population of Hakka has not been determined, it is estimated that there are about 50 million Hakka worldwide. Although the Hakka population is an important component of Han populations, the anthropologic characteristics of Hakka have not been reported.

1 Subjects and methods

In May 2011, 86 individual anthropologic factors were determined in 650 male (305 from urban areas, 345 from rural areas) and 704 female (331 from urban areas, 373 from rural areas) Hakka adults living in Meizhou, Guangdong and Ganzhou, Jiangxi. Of the 86 factors, 17 were observed and 69 were measured. Only healthy native Hakka who had lived in the region for more than three generations were enrolled. The subjects were selected using a random sampling method. The study was carried out in strict accordance with the methods described by Martin [2], "anthropometric methods" [3], and the "Anthropometric Manual" [4]. Data were statistically analyzed using Excel 2003 and SPSS version 17.0.

We also obtained anthropometric data for 14 factors in 16 North-Asian ethnic groups and 16 South-Asian ethnic groups as well as 11 indices for 11 North-Asian ethnic groups with 19 South-Asian ethnic groups. These factors were compared with those measured in Hakka. As most anthropologic data are collected for ethnic populations in rural regions of China, information obtained in Hakka living in villages was compared with that of other ethnic groups.

2 Results

The results of the 17 subjectively assessed factors in male and female Hakka are listed in Table 1. Objectively measured items, corresponding to the dimensions of the head/facial and body, are shown in Table 2. The 24 indices derived from objective measurements of the head/facial and body are shown in Table 3. The distributions of Hakka according to specific head/facial and body indices are shown in Table 4. Table 5 compares the anthropologic characteristics of Hakka with those of North-Asian and South-Asian ethnic groups. The loading scores for the first three eigenvectors among each of the 28 ethnic groups are presented in Table 6 for males and females separately. Score plots for the first and second principal components are shown in Figures 1–4.

Among Hakka adults, few had an eye fold on the upper eyelid, but a large proportion had a mongoloid fold. The opening height of eye slit was narrow in most subjects and most had prominent external angles. Nasal root height was classified as medium with straight bridges in the majority of adults. The nasal base was upturned in most men. The distributions of the three types of nasal bases in women were relatively similar. The proportions of subjects with a medium or high alae nasi were relatively high, and were similar. Males with a maximum nostril diameter were frequently classified as transverse and oblique. The majority of females were classified as transverse and they had relatively wide alae nasi. In males, the round lobe type was the most common. Upper lip skin height was mostly classified as medium. Most of the lips were thin, hair was black, the eyes were brown, and the skin was yellowish.

According to the mean values of the head/facial and body indices shown in Table 3, the subjects were classified into specific types, which are summarized in Table 4. In terms of head/facial indices, male and female Hakka were of the hypsicephalic (based on the length-height index of the head) and metriocephalic (based on the breadth-height index of the head) types, and generally showed mesoprosopy (based on the morphological face index) and mesorrhiny (based on the height-breadth index of nose). The length-breadth index of the head of females and rural males corresponded to mesocephaly, whereas that of urban males corresponded to brachycephaly. In terms of body indices, males and females had a long trunk, were classified as the subbrachyskelic type, and had a medium shoulder breadth. Men and urban women had a medium chest circumference and a narrow distance between iliac crests, whereas rural women had a broad chest circumference and a medium distance between iliac crests.

3 Discussion

3.1 Physical differences between urban and rural Hakka

In comparisons of urban and rural Hakka of the same sex, the indices were generally higher than or were similar in urban Hakka to rural Hakka. Only the breadth of cresta iliaca breadth was lower in urban females than in rural

Table 1 Distributions of the 17 subjective factors in Hakka (*n*, %)

Index	Type	Male				Female			
		Urban		Rural		Urban		Rural	
		n	%	*n*	%	*n*	%	*n*	%
Eyefold of the upper eyelid	no	152	49.8	175	50.7	148	44.7	187	50.1
	yes	153	50.2	170	49.3	183	55.3	186	49.9
Mongoloid fold	no	147	48.2	161	46.7	163	49.2	163	43.7
	yes	158	51.8	184	53.3	168	50.8	210	56.3
Opening height of eyeslits	wide	11	3.6	11	3.2	46	13.9	27	7.2
	narrow	189	62.0	233	67.5	133	40.2	217	58.2
	middle	105	34.4	101	29.3	152	45.9	129	34.6
Direction of eyeslits	internal angle	2	0.7	2	0.6	1	0.3	1	0.3
	level	88	28.9	81	23.5	46	13.9	75	20.1
	external angle	215	70.5	262	75.9	284	85.8	297	79.6
Nasal root height	low	44	14.4	51	14.8	123	37.2	157	42.1
	high	36	11.8	38	11.0	2	0.6	10	2.7
	middle	225	73.8	256	74.2	206	62.2	206	55.2
Nasal profile	concave	18	5.9	19	5.5	98	29.6	109	29.2
	protruding	25	8.2	23	6.7	7	2.1	4	1.1
	straight	262	85.9	303	87.8	226	68.3	260	69.7
Zygomatic projection	projecting	63	20.7	61	17.7	116	35.0	139	37.3
	tiny	97	31.8	123	35.7	103	31.1	132	35.4
	middle	131	43.0	110	31.9	106	32.0	110	29.5
Nasal base	prolapse	103	33.8	114	33.0	103	31.1	134	35.9
	level	162	53.1	190	55.1	119	36.0	124	33.2
	upturned	83	27.2	92	26.7	115	34.7	107	28.7
Height of alae nasi	low	39	12.8	34	9.9	53	16.0	78	20.9
	high	133	43.6	149	43.2	128	38.7	165	44.2
	middle	133	43.6	162	47.0	150	45.3	130	34.9
Maximal diameter of nostrils	transverse	119	39.0	152	44.1	181	54.7	231	61.9
	oblique	135	44.3	152	44.1	119	36.0	125	33.5
	vertical	51	16.7	41	11.9	31	9.4	17	4.6
Breadth of alae nasi	narrow	5	1.6	18	5.2	19	5.7	12	3.2
	middle	72	23.6	84	24.3	139	42.0	146	39.1
	wide	228	74.8	243	70.4	173	52.3	215	57.6
Lobe types	square	32	10.5	33	9.6	17	5.1	18	4.8
	triangle	120	39.3	145	42.0	155	46.8	154	41.3
	round	153	50.2	167	48.4	159	48.0	201	53.9
Upper lip skin height	low	25	8.2	20	5.8	55	16.6	67	18.0
	middle	254	83.3	305	88.4	268	81.0	297	79.6
	high	26	8.5	20	5.8	8	2.4	9	2.4
Thickness of lips	thin	167	54.8	171	49.6	240	72.5	270	72.4
	middle	128	42.0	151	43.8	91	27.5	95	25.5
	thick	10	3.3	23	6.7	0	0.0	8	2.1
Hair color	black	303	99.3	342	99.1	330	99.7	371	99.5
	palm black	2	0.7	3	0.9	1	0.3	2	0.5
	palm	0	0.0	0	0.0	0	0.0	0	0.0
Eye color	brown	191	62.6	202	58.6	216	65.3	224	60.1
	black brown	105	34.4	125	36.2	108	32.6	139	37.3
	shallow	9	3.0	18	5.2	7	2.1	10	2.7
Skin color	dark yellow	43	14.1	56	16.2	7	2.1	12	3.2
	yellow	198	64.9	242	70.1	210	63.4	261	70.0
	shallow yellow	64	21.0	47	13.6	114	34.4	100	26.8

Table 2 Objectively measured factors in Hakka (mm, $\bar{x} \pm SD$)[a)]

Martin No.	Index	Male					Female				
		Urban		Rural		u	Urban		Rural		u
		$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	
1	Head length	189.2	6.0	188.1	6.5	2.24*	180.3	6.1	179.9	6.0	0.88
3	Head breadth	153.0	6.6	151.4	6.5	3.11**	145.5	6.2	145.3	5.8	0.44
4	Minimum frontal breadth	109.0	6.2	109.0	5.7	0.00	106.4	5.6	106.6	5.6	0.47
6	Face breadth	143.9	6.2	143.3	5.6	1.29	138.0	5.2	137.0	5.3	2.52*
8	Bigonial breadth	113.8	5.9	112.4	6.0	3.00**	109.5	5.5	108.1	5.7	3.31**
9	Interocular breadth	34.4	3.2	34.2	3.1	0.81	33.5	2.8	33.2	2.9	1.40
10	External binocular breadth	94.9	5.8	94.7	6.0	0.43	91.8	5.5	91.5	5.6	0.72
13	Nose breadth	40.5	3.1	39.8	3.2	2.83**	37.4	3.2	37.4	2.8	0.00
14	Mouth breadth	52.8	3.9	52.0	3.9	2.61**	50.0	3.9	49.4	3.6	2.11*
15	Auricular height	125.7	7.1	125.8	9.9	0.15	121.4	6.4	121.7	5.9	0.64
17	Physiognomic facial height	187.3	7.7	185.8	6.9	2.60**	180.6	7.0	179.3	7.4	2.39*
18	Morphological facial height	123.4	7.8	121.8	7.6	2.64**	114.9	6.7	114.5	6.7	0.79
21	Nose height	55.2	5.1	53.8	4.7	3.62**	51.4	5.1	50.8	5.1	1.56
	Nose length	49.4	4.9	48.2	4.4	3.27**	46.0	4.4	45.4	4.6	1.77
	Nasal depth	11.2	2.2	10.6	1.9	3.70**	9.5	1.9	9.3	1.9	1.39
	Upper lip height	15.2	2.9	14.6	2.5	2.81**	13.9	2.5	13.4	2.5	2.65**
25	Lip height	15.3	3.3	15.0	3.4	1.14	14.2	3.0	14.2	3.3	0.00
	Thickness of lips	7.3	1.6	7.1	1.8	1.50	6.7	1.4	6.6	1.7	0.86
29	Physiognomic ear length	66.3	5.0	65.6	5.2	1.75	62.7	5.1	62.1	5.4	1.52
30	Physiognomic ear breadth	31.6	2.9	30.7	3.0	3.89**	29.8	3.0	29.4	2.8	1.82
45	Head circumference	555.2	15.8	554.3	16.7	0.71	536.7	16.4	536.0	14.7	0.59
1	Stature	1658.3	62.1	1645.0	62.4	2.72**	1550.6	58.6	1537.4	56.4	3.04**
2	Tragion height	1532.5	60.3	1519.2	61.0	2.79**	1429.2	57.4	1415.7	56.2	3.15**
8	Acromion height	1359.8	54.4	1347.2	56.5	2.89**	1267.3	52.0	1255.8	51.6	2.94**
4	Suprasternal height	1358.3	53.3	1346.0	54.8	2.90**	1267.1	50.6	1257.2	49.1	2.63**
7	Span of arms	1690.9	66.2	1684.8	70.4	1.14	1562.8	65.9	1552.7	60.6	2.11*
9	Radiale height	1037.3	47.0	1023.4	44.1	3.87**	968.6	41.9	959.2	41.7	2.98**
10	Radiale stylion height	799.8	39.9	787.9	37.8	3.89**	751.1	37.6	743.1	37.4	2.82**
11	Middle finger tip height	625.3	37.6	614.1	35.3	3.90**	588.2	35.9	579.9	34.4	3.12**
13	Iliospinale anterior height	904.1	37.3	895.7	41.3	2.72**	849.1	39.7	839.9	38.8	3.10**
15	Tibial height	450.9	22.9	448.5	24.6	1.29	416.7	22.7	413.2	20.8	2.12*
16	Height of foot	69.9	4.6	69.2	4.3	2.00*	64.5	4.0	64.2	3.8	1.02
23	Sitting height	902.5	34.7	892.5	35.0	3.65**	846.5	32.2	841.4	31.9	2.11*
25	Ht. sup. notch above sit. plane	602.5	27.8	593.4	29.5	4.05**	563.0	26.2	561.2	25.7	0.92
35	Shoulder breadth	380.1	18.0	377.7	18.4	1.68	346.3	14.8	345.4	14.5	0.81
36	Chest breadth I	271.7	19.2	268.8	20.1	1.88	249.2	17.0	248.5	17.2	0.54
40	Cresta iliaca breadth	272.1	21.3	272.1	20.7	0.00	268.7	22.4	272.6	21.2	2.36*
45	Upper extremity length	734.5	31.3	733.1	37.6	0.52	679.1	32.5	675.9	30.9	–1.33
46	Total arm length	560.1	27.6	559.3	30.5	0.35	516.2	26.6	512.7	25.5	1.78
47	Upper arm length	322.5	20.6	323.8	19.7	0.82	298.7	17.9	296.6	16.7	1.60
48	Forearm length	237.5	20.0	235.5	15.1	1.42	217.5	14.3	216.0	13.9	1.41
49	Hand length	174.4	14.8	173.8	14.9	–0.51	162.9	11.9	163.2	11.9	0.33
52	Hand breadth at metacarpale	80.0	4.0	80.3	4.4	0.91	73.0	3.9	73.5	3.8	1.72
53	Lower extremity length	868.8	33.4	861.6	37.2	2.60**	821.4	36.5	813.0	35.3	3.10*
54	Total leg length	800.8	34.5	793.4	38.5	2.58*	753.1	37.2	744.6	36.4	3.06**
55	Thigh length	421.5	23.2	415.8	28.4	2.81**	402.1	25.0	396.8	24.2	2.85**
56	Leg length	381.0	22.2	379.3	23.8	0.94	352.2	22.2	349.0	20.1	2.00*
58	Foot length	237.6	10.3	236.4	10.2	1.49	218.9	10.3	218.6	10.3	0.39
59	Foot breadth	93.6	5.3	93.2	5.7	0.93	85.9	4.8	85.9	5.0	0.00
61	Chest circumference III	880.5	70.1	868.6	69.2	2.17*	863.1	66.7	863.4	67.4	0.06
63	Neck girth I	349.7	24.8	346.3	24.2	1.76	317.9	22.3	317.0	22.3	0.53
65	Biceps circumference	270.5	26.6	267.2	25.6	1.61	259.3	25.3	257.0	28.9	1.13
66	Maximum forearm circumference	243.8	20.9	243.3	20.7	0.31	225.2	18.4	224.1	20.0	0.76

(*To be continued on the next page*)

(*Continued*)

Martin No.	Index	Male					Female				
		Urban		Rural		*u*	Urban		Rural		*u*
		$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	
68	Maximum thigh circumference	506.6	40.9	496.5	39.9	3.18*	503.1	41.0	495.7	39.5	2.43*
69	Calf circumference	339.3	27.2	338.9	27.8	0.19	329.6	24.5	329.1	24.0	0.27
	Chest circumference at inspiration	920.7	70.4	906.9	67.8	2.54*	897.5	66.7	897.4	66.7	0.02
	Chest circumference at expiration	858.6	70.4	844.3	70.0	2.59**	845.2	68.3	843.4	68.3	0.35
	Abdominal circumference	823.5	90.8	821.1	87.0	0.34	799.0	92.1	804.6	102.3	0.76
	Hip circumference	932.6	61.6	926.0	54.7	1.44	922.2	62.2	925.5	61.1	0.71
	Maximum biceps circumference	298.2	27.4	296.8	26.0	0.67	277.4	27.4	276.4	30.0	0.46
	Facial skinfold	12.4	3.1	11.8	2.9	2.54*	13.3	2.7	12.9	2.7	1.96*
	Triceps skinfold	11.7	3.7	11.6	3.9	0.34	14.8	3.3	14.4	3.6	1.54
	Biceps skinfold	8.0	3.0	7.8	2.9	0.86	10.4	3.0	10.0	2.9	1.79
	Subscapular skinfold	14.7	4.6	13.9	4.1	2.33*	16.8	3.8	16.4	4.2	1.33
	Suprailiac skinfold	13.4	5.0	13.1	5.0	0.76	16.1	4.2	15.9	4.6	0.60
	Calf skinfold	9.1	3.4	8.5	3.3	2.28*	12.1	3.8	11.2	3.4	3.29*
	Biep. breadth of humerus	64.1	4.1	64.2	4.1	0.31	56.8	4.4	57.1	4.1	0.93
	Biep. breadth of femur	94.1	6.0	92.9	5.9	2.56*	88.5	6.1	87.2	6.4	2.76**
	Body weight (kg)	62.9	9.6	60.8	8.9	2.88*	53.9	7.9	53.7	7.9	0.34

a) The *u* test was used to compare values between urban and rural Hakka. *, $P<0.05$; **, $P<0.01$ for comparisons between urban and rural Hakka. As skinfold thickness was not normally distributed, the geometric mean and the standard deviation of the geometric mean are shown.

Table 3 Values of the 24 indices of the head/facial and body ($\bar{x} \pm$SD)

Index	Male				Female			
	Urban		Rural		Urban		Rural	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Length- breadth index of head	81.0	4.1	80.6	4.3	80.8	4.4	80.9	4.4
Length-height index of head	66.5	3.8	66.9	5.6	67.4	3.8	67.7	3.7
Breadth-height index of head	82.3	4.9	83.2	6.9	83.5	5.2	83.8	4.5
Transverse frontoparietal index	71.3	4.1	72.0	4.1	73.2	3.7	73.4	3.7
Physiognomic facial index	130.3	6.9	129.8	6.2	131.0	6.2	131.1	6.8
Morphological facial index	85.9	6.1	85.1	5.6	83.3	5.4	83.7	5.3
Transverse cephalo-facial index	94.1	3.6	94.7	3.9	94.9	3.7	94.4	3.5
Vertical cephalo-facial index	98.4	7.9	97.3	9.1	94.9	7.4	94.3	6.2
Zygomatico-frontal index	75.8	3.9	76.1	3.6	77.2	3.7	77.8	3.8
Height-breadth index of nose	73.9	8.8	74.5	8.6	73.5	8.6	74.4	9.1
Lip index	29.2	7.0	29.0	6.9	28.6	6.6	29.0	7.2
Physiognomic index of ear	47.8	4.2	46.9	4.4	47.7	4.4	47.6	4.5
Stature-sitting height index	54.4	1.2	54.3	1.3	54.6	1.2	54.7	1.3
Stature-weight index	379.1	53.7	369.5	50.4	347.5	49.0	349.1	50.0
Stature-chest circumference index	53.1	4.3	52.9	4.5	55.7	4.8	56.2	4.9
Stature-shoulder breadth index	22.9	1.0	23.0	1.0	22.3	0.8	22.5	0.9
Stature-cristal index	16.4	1.3	16.6	1.3	17.3	1.5	17.8	1.5
Acromio-cristal index	71.6	5.2	72.1	5.8	77.7	6.3	79.0	6.3
Manouvrier's skelic index	83.8	3.9	84.4	4.9	83.2	4.2	82.8	4.2
Sitting height-lower extremity length index	1.2	0.1	1.2	0.1	1.2	0.1	1.2	0.1
Vervaeck's index	91.1	9.1	89.8	8.9	90.5	9.1	91.2	9.4
BMI	22.9	3.2	22.5	3.1	22.4	3.3	22.7	3.4
Constitutional index	16.0	13.8	17.9	13.5	14.9	14.2	13.7	14.7

Table 4 Classification of head/facial and body indices of Hakka (*n*, %)

Index	Type	Male				Female			
		Urban		Rural		Urban		Rural	
		n	%	*n*	%	*n*	%	*n*	%
Length-breadth index of head	Dolichocephaly (71.0–75.9)	26	8.5	37	10.7	39	11.8	39	10.5
	Mesocephaly (76.0–80.9)	138	45.2	151	43.8	134	40.5	163	43.7
	Brachycephaly (81.0–85.4)	101	33.1	115	33.3	111	33.5	120	32.2
	Hyperbrachycephaly (85.5–90.9)	40	13.1	42	12.2	47	14.2	51	13.7
1ength-height index of head	Chamaecephalic type (⩽57.9)	4	1.3	10	2.9	2	0.6	1	0.3
	Orthocephalic type (58.0–62.9)	59	19.3	48	13.9	35	10.6	27	7.2
	Hypsicephalic type (⩾63.0)	242	79.3	287	83.2	294	88.8	345	92.5
Breadth-height index of head	Tapeinocephalic type (⩽78.9)	77	25.2	75	21.7	64	19.3	50	13.4
	Metriocephalic type (79.0–84.9)	140	45.9	152	44.1	139	42.0	176	47.2
	Aerocephalic type (⩾85.0)	88	28.9	118	34.2	128	38.7	147	39.4
Morphological facial index	Hypereuryprosopy (male⩽78.9, female⩽76.9)	38	12.5	53	15.4	35	10.6	38	10.2
	Euryprosopy (male 79.0–83.9, female 77.0–80.9)	83	27.2	102	29.6	82	24.8	81	21.7
	Mesoprosopy (male⩽84.0–87.9, female 81.0–84.9)	76	24.9	91	26.4	88	26.6	107	28.7
	Leptoprosopy (male 88.0–92.9, female 85.0–89.9)	71	23.3	72	20.9	86	26.0	101	27.1
	Hyperleptoprosopy (male⩾93.0, female⩾90.0)	37	12.1	27	7.8	40	12.1	46	12.3
Height-breadth index of nose	Hyperleptorrhiny (40.0–54.9)	1	0.3	1	0.3	2	0.6	1	0.3
	Leptorrhiny (55.0–69.9)	112	36.7	104	30.1	125	37.8	135	36.2
	Mesorrhiny (70.0–84.9)	151	49.5	193	55.9	165	49.8	177	47.5
	Chamaerrhiny (85.0–99.9)	41	13.4	47	13.6	39	11.8	60	16.1
Stature-sitting height index	Short trunk (male⩽51.0, female⩽52.0)	0	0.0	2	0.6	6	1.8	3	0.8
	Middle trunk (male 51.1–53.0, female 52.1–54.0)	37	12.1	41	11.9	94	28.4	97	26.0
	Long trunk (male⩾53.1, female⩽54.1)	268	87.9	302	87.5	231	69.8	273	73.2
Manouvrier's skelic index	Hyperbrachyskelic type (⩽74.9)	2	0.7	6	1.7	8	2.4	13	3.5
	Brachyskelic type (75.0–79.9)	50	16.4	39	11.3	54	16.3	80	21.4
	Subbrachyskelic type (80.0–84.9)	136	44.6	157	45.5	163	49.2	178	47.7
	Mesatiskelic type (85.0–89.9)	99	32.5	116	33.6	85	25.7	86	23.1
	Submakroskelic type (90.0–94.9)	16	5.2	24	7.0	20	6.0	16	4.3
	Makroskelic type (95.0–99.9)	2	0.7	2	0.6	0	0.0	0	0.0
	Hypermakroskelic type (⩾100.0)	0	0.0	1	0.3	1	0.3	0	0.0
Stature-chest circumference index	Narrow chest circumference (<51)	98	32.1	122	35.4	60	18.1	59	15.8
	Medium chest circumference (51–56)	134	43.9	135	39.1	122	36.9	114	30.6
	Broad chest circumference (>56)	73	23.9	88	25.5	149	45.0	200	53.6
Stature-shoulder breadth index	Narrow shoulder breadth (male⩽21.9, female⩽21.4)	48	15.7	53	15.4	44	13.3	45	12.1
	Medium shoulder breadth (male 22.0–23.0, female 21.5–22.5)	114	37.4	126	36.5	143	43.2	147	39.4
	Broad shoulder breadth (male⩾23.1, female⩾22.6)	144	47.2	166	48.1	144	43.5	181	48.5
Stature-crista iliaca breadth index	Narrow distance between iliac crests (male⩽16.4, female⩽17.4)	142	46.6	147	42.6	180	54.4	153	41.0
	Medium distance between iliac crests (male 16.5–17.5, female 17.5–18.5)	105	34.4	113	32.8	83	25.1	99	26.5
	Broad distance between iliac crests (male⩾17.6, female⩾18.6)	58	19.0	85	24.6	68	20.5	121	32.4
Stature type	Shortest (male⩽1499, female⩽1399)	1	0.3	6	1.7	3	0.9	3	0.8
	Short (male 1500–1599, female 1400–1489)	52	17.0	67	19.4	36	10.9	68	18.2
	Sub-middle (male 1600–1639, female 1490–1529)	60	19.7	82	23.8	83	25.1	93	24.9
	Middle (male 1640–1669, female 1530–1559)	60	19.7	68	19.7	59	17.8	71	19.0
	Hypermiddle (male 1670–1699, female 1560–1589)	53	17.4	51	14.8	58	17.5	77	20.6
	Tall (male 1700–1799, female 1590–1679)	75	24.6	68	19.7	89	26.9	60	16.1
	Tallest (male⩾1800, female⩾1680)	4	1.3	3	0.9	3	0.9	1	0.3

Table 5 Comparison of anthropometric indices between Hakka and North-Asian or South-Asian ethnic groups (mm, $\bar{x}$)

Variable	Male			Female		
	North Asian type	South Asian type	Hakka	North Asian type	South Asian type	Hakka
Head length	185.7	185.4	188.1	176.5	177.7	179.9
Head breadth	154.4	149.7	151.4	147.4	143.9	145.3
Minimum frontal breadth	111.7	104.5	109.0	108.1	102.1	106.6
Face breadth	143.6	140.5	143.3	136.2	133.8	137.0
Morphological facial ht.	125.0	122.2	121.8	115.8	115.4	111.7
Nose breadth	36.0	38.7	39.8	33.0	35.7	37.4
Nose height	54.1	53.6	53.8	50.1	50.0	50.8
Lip height	15.0	17.1	15.0	14.6	16.1	14.2
Mouth breadth	50.1	52.9	52.0	47.7	50.5	49.4
Interocular breadth	34.4	35.1	34.2	33.6	34.1	33.2
Stature	1670.6	1612.3	1645.0	1553.1	1508.5	1537.4
Sitting height	892.6	856.2	892.5	839.2	803.1	841.4
Shoulder breadth	378.4	368.6	377.7	344.6	336.2	345.4
Cresta iliaca breadth	284.9	270.5	272.1	280.7	273.4	272.6
Length- breadth index of head	85.5	80.8	80.6	86.5	80.9	80.9
Length-height index of head	68.2	67.5	66.9	69.7	67.7	67.7
Breadth-height index of head	79.5	83.6	83.2	80.9	83.7	83.8
Transverse frontoparietal index	71.2	70.2	72.0	72.0	70.8	73.4
Physiognomic facial index	132.4	134.5	129.8	132.6	135.0	131.1
Morphological facial index	84.8	86.3	85.1	83.8	85.4	83.7
Height-breadth index of nose	69.9	72.3	74.5	68.9	71.6	74.4
Stature-weight index	405.5	331.6	369.5	360.9	311.6	349.1
Stature-chest circumference index	54.2	52.6	52.9	53.9	53.2	56.2
Stature-cristal index	16.7	17.0	16.6	17.5	18.2	17.8
Manouvrier's skelic index	76.5	87.7	84.4	86.5	87.6	82.8

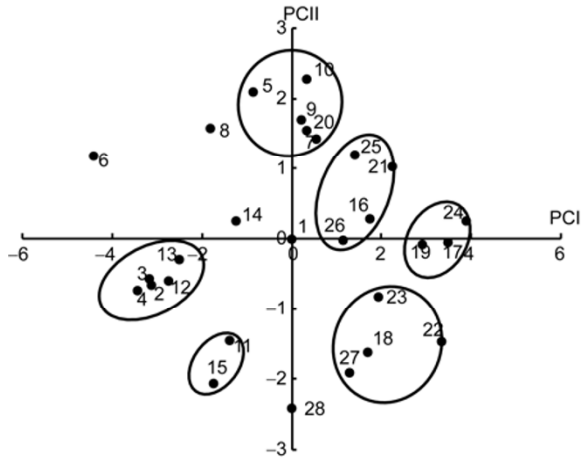

Figure 1 Loading plots for the first and second principal components in males.

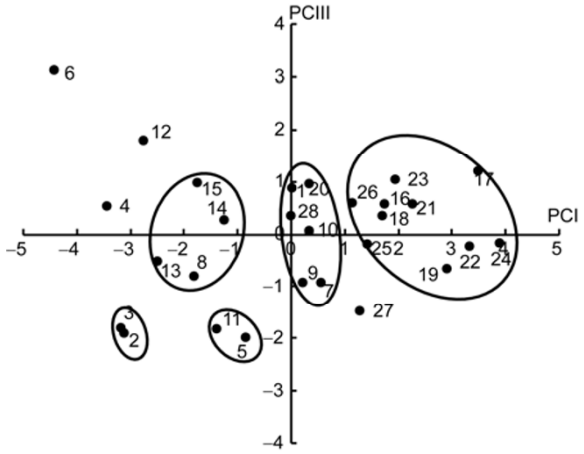

Figure 2 Loading plots for the first and third principal components in males.

females. The following indices were greater in urban males than in rural males: head length and breadth; breadths of the five sense organs; facial height; nose height and breadth; stature; length of the lower limbs; chest circumference; skinfold thicknesses of the face, triceps, back, and lower leg; femur breadth; and body weight. Facial breadth, bigonial breadth, mouth breadth, stature, length of the lower limbs, skinfold thickness, and breadth of the femur were greater in urban women than in rural women. Head height, eye and lip indices, ear length, upper-limb length, body/limb circumferences, skinfold thickness, and body breadths were similar between urban and rural Hakka.

3.2 Head/facial indices

Based on subjective facial factors, a large proportion of

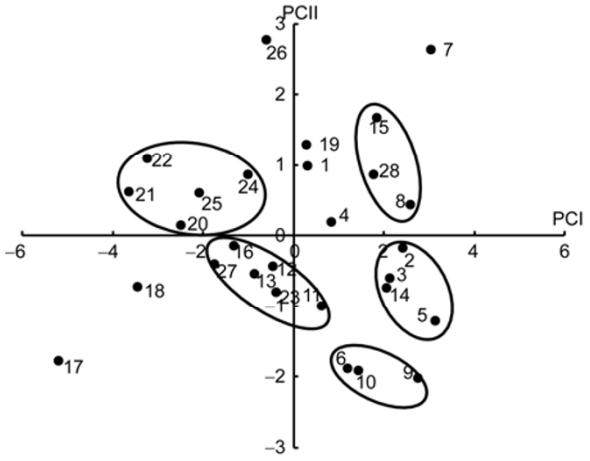

Figure 3 Loading plots for the first and second principal components in females.

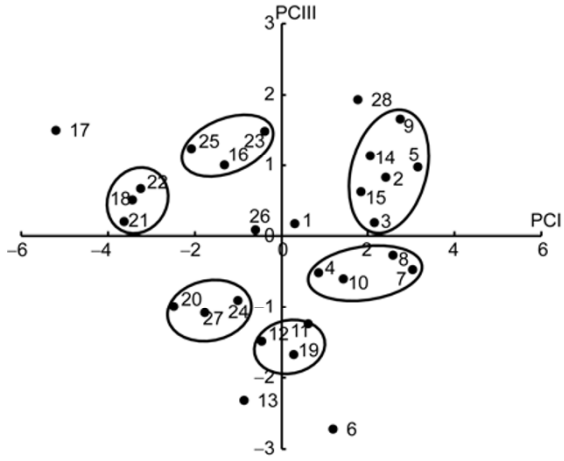

Figure 4 Loading plots for the first and third principal components in females.

Hakka had a mongoloid fold. The opening height of the eye slit was narrow in most subjects, but a prominent external angle was common. The nasal root height was generally classified as medium with a straight nasal bridge. The nasal base was often upturned and the lips were usually thin. These features are frequently found among Mongolian North-Asian ethnic populations. However, the alae nasi was relatively wide, a common characteristic of South-Asian ethnic populations.

In terms of objectively measured factors, the head length of male and female Hakka was generally greater than that of Mongolian North-Asian and South-Asian ethnic populations. However, the minimum frontal breadth, facial breadth, lip height, and interocular breadth were similar to those of North-Asian ethnic populations. Head breadth, morphological facial height, nose breadth, mouth breadth, and nose height of male Hakka were similar to those of South-Asian ethnic groups. The head breadth, nose breadth, and mouth breadth of female Hakka were similar to those of South-Asian ethnic groups.

The foreheads and faces of Hakka were quite large, but the lip height and interocular breadth were small, similar to those of North-Asian populations. However, the nose and mouth breadths were quite large, consistent with those of South-Asian ethnic populations. Overall, the head and facial features of Hakka subjects were closer to those of North-Asian populations than South-Asian population.

The zygomaticofrontal, physiognomic facial, and morphological facial indices of male and female Hakka were similar to those of North-Asian ethnic populations. However, the length-breadth index of the head, length-height index of the head, breadth-height index of the head, and height-breadth index of the nose were closer to those of South-Asian than North-Asian ethnic populations. Overall, the head indices of Hakka were closer to those of South-Asian ethnic populations, and their facial index was close to that of North-Asian populations.

3.3 Body indices

According to the objectively measured body indices, male and female Hakka living in urban and rural settings were mostly classified as medium height. Stature was between those of North-Asian and South-Asian ethnic populations. Sitting height and shoulder breadth were similar to those of Chinese Mongolia North-Asian ethnic populations. The cresta iliaca breadth was similar to that of South-Asian ethnic populations. Therefore, in terms of objectively measured body indices, the Hakka were closer in appearance to North-Asian than South-Asian ethnic populations.

The stature-cristal index of male Hakka was similar to that of North-Asian ethnic populations, but stature-chest circumference index and Manouvrier's index were closer to those of South-Asian ethnic populations. The stature-weight index was between that of North-Asian and South-Asian ethnic populations. Among Hakka females, the stature-chest circumference index was high, Manouvrier's index was low, and the stature-cristal index was between those of North-Asian and South-Asian ethnic populations. The stature-weight index was closer to that of North-Asian ethnic populations. Overall, these findings indicate that body indices of Hakka were between those of North-Asian and South-Asian ethnic groups.

3.4 Principal component analyses of Hakka and Chinese ethnic populations

Thirteen items (head length; head breadth; minimum frontal breadth; face breadth; morphological facial height; nose breadth; nose height; mouth breadth; interocular breadth; stature; sitting height; shoulder breadth; and cresta iliaca breadth) determined in 28 Chinese ethnic populations were

included in the principal component analysis. The following ethnic populations (ID number) were evaluated: (1) Hakka, (2) Russia [5], (3) Uzbek [6], (4) Uygur [7], (5) Tajik [8], (6) Xibe [9], (7) Tu [10], (8) Sarah [11], (9) Baoan [12], (10) Dongxiang [13], (11) Hui (Ningxia) [14], (12) Mongolia (Inner Mongolia) [15], (13) Daur [16], (14) Oroqen [17], (15) Hezhen [18], (16) Gelao [19], (17) Yi (Guangxi) [20], (18) Shui [21], (19) Lahu [22], (20) Naxi [23], (21) Achang [24], (22) Dong (Guangxi) [25], (23) Li [26], (24) Deang [4], (25) Shes [27], (26) Wa [28], (27) Bouyei [29], and (28) Han (Hainan) [30]. These ID numbers are used in Figures 1–4.

3.4.1 Males

Principal components (PC)-I, PCII, and PCIII accounted for 40.7%, 13.3%, and 11.2% of the total variance in the model, with a cumulative contribution of 65.1%. The indices included in the first principal component (PCI) that had relatively high loading values were stature (–0.397), sitting height (–0.374), head breadth (–0.364), cresta iliaca breadth (–0.362), shoulder breadth (–0.342), and face breadth (–0.341). The loading values for these six indices were similar, and PCI included the stature and breadth of the body, as well as the breadths of the head and face. The stature and breadth of the body, as well as the head and face breadths, decrease with increasing PCI values. The indices in PCII that had relatively high loading values were head length (0.587), morphological facial height (0.475), and nose height (0.378). The head is longer, and the face and nose are more prominent with increasing PCII values. The indices in PCIII that had relatively high loading values were nose breadth (0.554) and interocular breadth (0.493) (Table 6).

Using PCI and PCII scores as the horizontal and vertical axes, respectively, the 28 ethnic groups could be divided into six groups (Figure 1). Groups 1 (Yi, Lahu, and De'ang), 2 (Gelao, Achang, She, and Wa), and 3 (Shui, Dong, Li, and Bouyei) included South-Asian ethnic populations. These groups were characterized by high (or relatively high) PCI values, suggesting short (or relatively short) stature, together with small body and head/facial breadths. Groups 4 (Tajik, Baoan, Dongxiang, Tu, and Lahu), 5 (Russian, Uzbek, Uygur, Mongolia, and Daur), and 6 (Hui [Ningxia] and Hezhe) were mainly composed of North-Asian ethnic populations. These groups were characterized by medium or relatively low PCI values, suggesting medium or relatively tall stature, and large body and head/facial breadths. The PCII values of the South-Asian ethnic populations showed a wide range, indicating marked variations in head length, face height, and nose height. By contrast, the PCII values for the North-Asian ethnic populations were fairly similar. The Hakka population was located close to the interest of the PCI and PCII axes, indicating the characteristics of Hakka are between the other six groups. Accordingly, the physical characteristics of Hakka share some features of or are between those of North-Asian and South-Asian ethnic populations, with a medium stature and body breadth, medium head/facial breadth, and medium head length, face height, and nose height.

When PCI and PCIII were used as the horizontal and vertical axes, respectively, the 28 populations could be divided into five groups (Figure 2). Groups 1, 2, and 3 in Figure 1 formed a single group in Figure 2. The PCIII value of Hakka was relatively high, suggesting that the nose and interocular breadths were relatively large. Hakka were included in a group that also included Bouyei, Han (Hainan), Tu, Baoan, and Dongxiang. Tu, Baoan, and Dongxiang are North-Asian ethnic populations and the physique of Hainan Han is similar to that of North-Asian ethnic populations. Therefore, although the physique of Hakka subjects was between those of South-Asian and North-Asian ethnic populations, it was closer to that of North-Asian ethnic populations.

3.4.2 Females

PCI, PCII, and PCIII accounted for 39.7%, 12.4%, and 11.6% of the variance in the model, respectively, with a cumulative contribution of 63.7%. PCI represented the height and breadth of the body, as well as head/facial breadths. PCII represented nose and interocular breadths. PCIII included head length and nose height. The distribu-

Table 6 Loading values for the first three eigenvectors for each index[a)]

Eigenvector	Head length	Head breadth	Min. frontal breadth	Face breadth	Morph. facial ht.	Nose breadth	Nose height	Mouth breadth	Interocular breadth	Stature	Sitting height	Shoulder breadth	Cresta iliaca b.
Male													
Eigenvector 1	0.071	–0.364	–0.297	–0.341	–0.060	0.225	–0.029	0.205	0.128	–0.397	–0.374	–0.342	–0.362
Eigenvector 2	0.587	–0.305	0.151	–0.222	0.475	–0.187	0.378	0.053	–0.016	0.132	0.154	–0.150	0.143
Eigenvector 3	0.038	0.122	–0.070	0.283	0.191	0.554	0.334	0.291	0.493	0.057	0.142	0.261	–0.155
Female													
Eigenvector 1	–0.194	0.337	0.260	0.315	–0.167	–0.219	–0.045	–0.331	–0.091	0.387	0.386	0.344	0.265
Eigenvector 2	0.049	0.148	–0.243	0.384	0.134	0.515	0.315	0.060	0.511	–0.038	0.027	0.347	0.008
Eigenvector 3	–0.521	0.307	–0.105	0.228	–0.256	0.319	–0.505	0.099	–0.148	–0.193	–0.152	–0.103	–0.214

a) Morph., morphological; b., breadth; ht., height.

tion of the 28 ethnic populations and the results of principal component analyses in females were consistent with those of males (Figures 3 and 4).

3.5 General characteristics of Hakka

The regional distribution of the physical characteristics of various ethnic populations in China has been reported. Zhao et al. [31] proposed that Chinese populations could be divided into two main groups, roughly divided into northern and southern populations, at a latitude of 30°, based on the distribution of blood Gm factors. Zhang et al. [32] also proposed that the modern Chinese population could be divided into northern and southern populations, with the Yangtze River serving as the boundary. Liu et al. [33] also supported this classification of northern and southern populations, but they emphasized that there were some regions of overlap, and there was a trend for a transition from the north to the south.

Chinese researchers have compared Hakka and other ethnic populations in China using molecular genetic methods. Li et al. [34] conducted analyses of mitochondrial DNA, which reflects maternal inheritance, to compare the genetic characteristics of Chaoshan, Cantonese, and Hakka in Guangdong with those of Taihang (Henan) and southern indigenous people. They found that Hakka populations frequently mixed with Cantonese and southern indigenous people.

Li et al. [35,36] compared the molecular genetic characteristics of the modern Han dialect with those of the Min and Hakka dialects. They found that people who spoke the Min dialect originated from northern Han immigrants. Principal components analysis of single nucleotide polymorphisms in the Y chromosome, which reflects paternal inheritance, revealed that speakers of the Hakka and Han dialects showed the greatest similarity. They also noted that Hakka were related to the Shes ethnic population, which used the Miao Yao dialect. The frequency of a 9 bp deletion in the mitochondrial region V, corresponding to maternal inheritance, was 19.7% in Hakka, which was very close to that of Shes but differed from that of Han. Most Hakka are descended from Han in the central region of China, but Shes have the greatest external influence on the characteristics of Hakka. Considering the extensive history of genetic exchange between northern Han and other North-Asian ethnic populations in China, the results of the present study are consistent with those reported by Xiaoyun Li and Hui Li.

In recent years, Jin et al. [37] have conducted extensive analyses of the genomes of >1700 Han individuals living in 26 provinces and cities in China. They found that the structure of the Han population was very complex, and could be broadly divided into northern, southern, and central (Jianghuai and Zhejiang) regions. The isolation, integration, and migration of different populations over the last 1000 years have inevitably led to marked genetic differences among Han individuals living in different regions. Interestingly, the results of the present study indicate that Hakka have retained the physical characteristics of northern Han populations better than the more common southern Han ethnic populations. A possible explanation for this is that Hakka populations have preserved their ethnic customs over time, including marriage within the same ethnicity.

The ancestral home of Hakka was in northern China. After moving south, Hakka tended to live together. Despite having many features of central Chinese culture, they have generally retained the physical characteristics of North-Asian populations. Inevitably, they have exchanged genes with local populations, mainly Shes, over many years in southern China. The hot and humid climate of southern China in summer has also contributed to changes in diet and working practices. These factors at least partly contribute to the changes in the physique of Hakka, including the increasing resemblance to South-Asian ethnic populations.

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